Candidate style answers

Statistical problem solving

Medium banded responses

Introduction

This resource has been produced by a senior member of the Core Maths examining team to offer teachers an insight into how the assessment objectives are applied. It has taken questions from the sample question paper and used them to illustrate how the questions might be answered and provide some commentary on what factors contribute to overall levels.

As these responses have not been through full moderation, they are banded to give an indication of the level of each response. Please note that this resource is provided for advice and guidance only and does not in any way constitute an indication of grade boundaries or endorsed answers.

The sample assessment material for these answers and commentary can be found on Teach Cambridge.

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(i) Show that the results from parts **(a)** and **(b)** and the modelling assumptions lead to the conclusion that the birds will reduce in numbers.

[3]

(ii) Give **two** comments about whether there is good evidence for the biologist to ask farmers to stop using insecticides near the wood.

[2]

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Sample answer for question 1

(a) $5 + 1 + 1 + 2 + 3 = 12$

(b) The number of fledglings is 0 + 2 + 3 + 8 + 15 = 28

(c) (i) At start, 12 females

New birds, $\frac{1}{2}$(2 + 3 + 8 + 15) are females = 14

Only 25% of these will survive predators so 25% of 14 = 3.5 breeding females.

This is not enough to replace the 12 females at the start so the population will decline.

(ii) No, a sample size of 12 is quite small; a larger sample would provide stronger evidence.

Commentary on the answer

(a) The frequencies are added correctly to show that there are 12 females.

(b) The products of fledglings per female and number of females are added correctly to find the right number of fledglings.

(c) (i) This answer has correctly used the information about birds lost to predators and has concentrated on the number of female birds to decide whether replacement takes place. However, the answer has not taken account of the assumption ‘a female breeds three times in her lifetime’.

(c) (ii) This answer has only one distinct comment about insufficient evidence. It is good practice to give the answer in the context of the question and suggest other factors that could be the cause.

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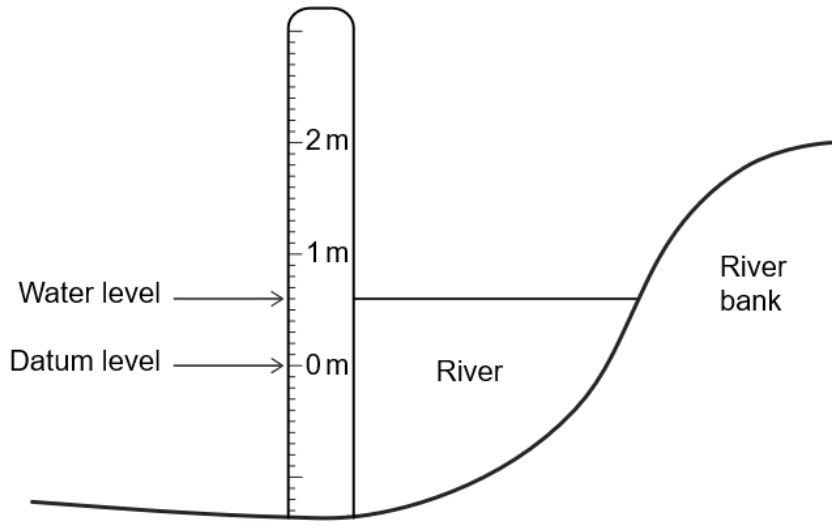
Question 2 (a)

A river flows through a town. If the height of the water level is more than 2 metres above a given datum level, the town will flood.



The cost of house insurance in this town increases.
The insurance companies say that this is because the risk of flooding is high.

The residents of the town decide to investigate the situation.
They want to be able to either:

- prove that the insurance companies are **not** correct or
- claim funding for flood defences.

The town's data records give the greatest height of the water above the datum level each year for the last 120 years.
The mean of these heights is 0.61 m.
The standard deviation is 0.48 m.
One of the residents uses the Normal distribution to model this situation.

(a) Use the Normal model to find the probability of the town flooding.

[3]

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Sample answer for question 2 (a)

(a) Mean = 0.61 Standard deviation = 0.48

$$z(2) = \frac{2 - 0.61}{0.48} = 2.895833$$

$$P(Z \leq 2.8985) = 0.9981$$

So, probability of a flood is 0.9981

Commentary on the answer

This answer has identified the values needed for working with the Normal distribution, correctly calculated the z value and found the corresponding probability. However, this probability is for ≤ 2m and flooding occurs when it is more than 2m, so it needs to be subtracted from 1.

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Question 2 (b)

(b) Use your answer to part **(a)** to determine if the statement below is **true** or **false**.

'The flood risk can be described as a once in 500 years event.'

Tick (ü) **one** box.

True ☐

False ☐

Show your reasoning.

[2]

Sample answer for question 2 (b)

(b) False, $\frac{1}{500} = 0.002$ which is much smaller than 0.9981

Commentary on the answer

Although the answer to part (a) is incorrect, this answer still attempts to show what once in 500 years represents as a decimal in order to make a comparison.

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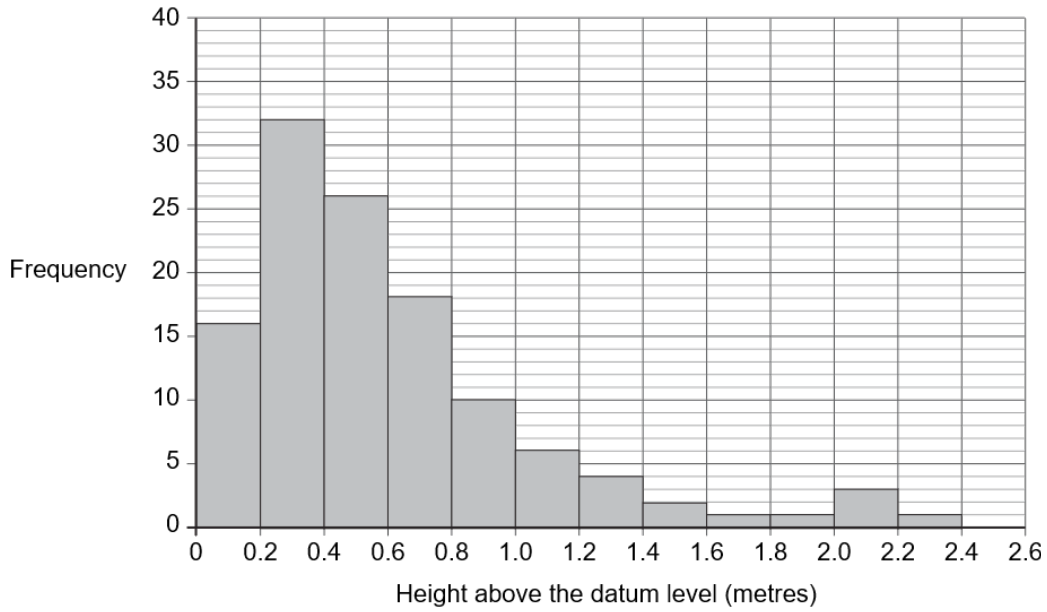
Question 2 (c)

(c) Another resident uses the data records to draw this frequency chart.
The chart shows the greatest heights above the datum level from the last 120 years.



(i) Use the frequency chart to find the probability of a flood.

[2]

(ii) Taking this new information into account, comment on the work the residents have done so far and advise them on what they should do.

[3]

Sample answer for question 2 (c)

(c) (i) $\frac{4}{120} = \frac{1}{30}$

(ii) The new information suggests that the model may not be accurate and may need to be refined. I would suggest that they use the data from more recent years only because there may have been changes in the surrounding area which has made flooding more likely, or changes in weather patterns over time.

Commentary on the answer

a) (c) (i) The information in the frequency chart is used correctly to find the right probability.

b) (c) (ii) This answer has correctly identified that the model may need to be refined and has also correctly suggested that more recent information would be best to use, with a reason. However, there is no reason given for suggesting that the model may need to be refined. Comments on the appropriateness rather than the accuracy of the model would be better as models do not need to be accurate, they

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just need to be helpful. The skewness in the diagram is a strong indicator that a Normal model is not appropriate and this should have been commented on.

Question 3 (a) to (c)

A psychology student has devised a test for how easily people do what they are told.

The test places each person in one of three categories: C, D and N.

C - People who will always do what they are told without questioning it.

D - People who will only do what they are told without question if they respect the person asking them.

N - People who will never do what they are told without first questioning it.

The student used the test in an experiment to find out if there are differences in how easily people who support six different rugby teams do as they are told.

He tried the test out on groups of rugby supporters attending rugby matches between the six different teams.

The student stood in the street outside rugby matches and gave out vouchers to participants to get them to take part in his test.

The table shows their results.

Team supported	**C**	**D**	**N**
England	0	0	20
France	6	8	6
Ireland	5	7	8
Italy	6	8	6
Scotland	3	11	6
Wales	10	5	5

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(a) Which sampling method did the student use?

Tick (ü) **one** box.

Opportunity	☐
Self-selected	☐
Cluster	☐
Simple random	☐
Quota	☐
Stratified	☐

[1]

(b) The information for England is an outlier.

Explain what this means.

[1]

(c) The student carries out a χ^2 test using the data.

State the null and alternative hypotheses for a χ^2 test.

[1]

Sample answer for question 3 (a) to (c)

(a) Self-selected

(b) England has no data in the C or D, everyone is N, all the others have some data in C and D.

(c) No hypotheses given.

Commentary on the answer

(a) Self-selected does not accurately describe the sampling method as the people were persuaded to take part with the offer of a voucher rather than choosing to do so.

(b) This answer describes the data in a way which is relevant to the question but does not go on to explain the term “outlier”.

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(c) There is no statement of null and alternative hypotheses.

Question 3 (d) to (g)

(d) **Table 3.1** shows the expected frequencies for the data with the outlier excluded.

Complete **Table 3.1**.

Table 3.1

Expected frequencies	**C**	**D**	**N**	**TOTAL**
France				
Ireland				
Italy			6.2	**20**
Scotland				**20**
Wales				
TOTAL	**30**	**39**		**100**

[2]

(e) **Table 3.2** shows the contributions to the test statistic for a χ^2 test.

Calculate the test statistic for a χ^2 test by first completing **Table 3.2**.

Table 3.2

Contributions to χ^2	**C**	**D**	**N**
France	0		0.006
Ireland	0.167	0.082	0.523
Italy	0		0.006
Scotland	1.5	1.313	0.006
Wales	2.667		0.232

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[2]

(f) Carry out the χ^2 test.

Use a 5% significance level.

[4]

(g) Make **two** comments on the conduct of the experiment.

[2]

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Sample answer for question 3 (d) to (g)

(d) $\frac{30 \times 20}{100} = 6$

$\frac{39 \times 20}{100} = 7.8$

$\frac{31 \times 20}{100} = 6.2$

Expected frequencies	C	D	N	TOTAL
France	6	7.8	6.2	**20**
Ireland	6	7.8	6.2	**20**
Italy	6	7.8	6.2	**20**
Scotland	6	7.8	6.2	**20**
Wales	6	7.8	6.2	**20**
TOTAL	**30**	**39**	**31**	**100**

(e) $\frac{(8 - 7.8)^2}{7.8} = 0.005128...$

$\frac{(5 - 7.8)^2}{7.8} = 1.005128...$

Contributions to χ^2	C	D	N
France	0	0.005	0.006
Ireland	0.167	0.082	0.523
Italy	0	0.005	0.006
Scotland	1.5	1.313	0.006
Wales	2.667	1.005	0.232

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$\chi^2 = 7.52$

(f) Degrees of freedom = 2 × 5 = 10

5% significance from the chi-squared table for 10df = 18.31

As 7.52 < 18.31 we can assume that the events are independent.

(g) A sample of 20 is quite small, plus the rugby fans are more likely to be male.

Commentary on the answer

(d) & (e) The correct values are calculated.

(f) The test statistic is tested at 5% significance level. However, the degrees of freedom are not correct. The conclusion is rather brief and refers to “events” – it is not clear what is meant by this. It is generally best to give the conclusion as a two-stage process; first stating the decision whether to reject the null hypothesis or not and then giving this in terms of the original situation – this final statement should make it clear that the decision is based on the evidence available.

(g) The second comment in this answer is relevant; the original question was about nationalities, but the sample has been about rugby fans – it would be better to go on to say that the sample is unlikely to be representative of the population. The first comment in the answer is not relevant; the sample used was 120 rugby fans; there were 20 from each nation but that is not the sample size. There is quite a lot that could be said about the possible introduction of bias during the experiment.

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Question 4

Use the **pre-release data** to answer the questions. A hard copy of the **pre-release data** is provided.

(a) The sum of the figures in the column headed "Population" in the pre-release data gives a total of 7 174 654 290.

Give **two** reasons why this is **not** the current world population.

[2]

(b) Is the statement below **true** or **false**?

'Over a quarter of the world's population lives in just two countries.'

Tick (ü) **one** box.

Justify your answer.

True ☐

False ☐

[3]

(c) (i) Calculate the number of births per year in Ghana.

[2]

(ii) Compare the number of births per year in Ghana to the number of births per year in the UK.

[2]

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Sample answer for question 4

(a) People will have been born since the data was collected, people will have died since the data was collected.

(b) $\frac{1}{4}$ of $7\,174\,654\,290 \approx 1.79$ bn
China and India

(c) (i) The birth rate in Ghana is 31.4 per thousand.

(ii) The birth rate in the UK is much lower at 12.22 per thousand.

Commentary on the answer

(a) This answer is correct but incomplete; both statements are really the same point about the population having changed in the time since the data was collected.

(b) This answer correctly works out one quarter of the world's population and identifies China and India as the two largest countries in terms of population. However, it does not show that the total population of China and India is over one quarter of the world's population, so the answer is not fully justified.

(c) This answer quotes the information in the table for births per thousand. However, it does not work out and compare the required quantities (the number of births per year).

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Question 5

In the **pre-release data**, GDP per capita is given by country.

(a) Explain how you would use a spreadsheet containing the pre-release data to calculate an estimate of the GDP per capita for the whole world.

[3]

(b) Explain what this figure represents.

[1]

(c) Demonstrate your method using data from Japan, Nigeria and Sri Lanka.

You can use the table provided to help you.

Country	**Sub region**				
Japan	East & South East Asia				
Nigeria	Africa (Sub-Saharan)				
Sri Lanka	South Asia				

[4]

Sample answer for question 5

(a) Use the spreadsheet to calculate the total wealth of the world and then divide this number by the population of the world.

(b) No explanation given.

(c)

A	B	C	D	
Country	**Population**	**GDP per capita**		
Japan	127 103 388	37 100	=b2*c2	
Nigeria	17 466 172	800	=b3*c3	
Sri Lanka	21 866 445	6500	=b4*c4	
	7 174 654 290		sum (d2:d4)	=d5/b5

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Commentary on the answer

(a) The explanation of the method at the start of this answer is correct; however, it is not specific enough – the step taken to calculate the total wealth needs to be stated.

(b) There is no statement of what the figure represents.

(c) The answer goes on to show a correct method, but it is incomplete and has used data values for Niger instead of Nigeria. The answer for GDP per capita for these three countries taken together has not been worked out so the method is incomplete.

Question 6 (a) and (b)

A student thinks that valuable insights can be obtained from the pre-release data.

In order to carry out a pilot investigation the student selects this sample of countries.

Algeria	Brazil	Costa Rica	Poland	Tonga
Bangladesh	Cambodia	France	Syria	Zambia
Barbados	Canada	New Zealand	Tajikistan	

(a) Why might the student want to use a sample for a pilot investigation when the full data set is available?

[1]

(b) Comment briefly on how it appears this sample was selected.

[1]

Sample answer for question 6 (a) and (b)

(a) It would be quicker to work with a smaller set of data.

(b) Random sample

Commentary on the answer

(a) This answer is not complete; when calculations are done on a spreadsheet, there is little difference in time taken between 14 countries and all the countries in the data set. The essential point here is that the research student does not yet know what information will be helpful and so a smaller number of countries will be easier to work with to start with.

(b) This answer misses the essential point that each country chosen is from a different sub region.

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Question 6 (c) and (d)

(c) The student uses this sample to investigate whether there is any association between the birth rate of a country and the life expectancy of its citizens.

They complete a hypothesis test using Spearman's rank correlation coefficient.

(i) Write down null and alternative hypotheses for a 2-tail test.

[1]

(ii) Complete the table to work out the test statistic.

Country	**Birth rate**	**Rank,** x	**Life expectancy**	**Rank,** y	$d=x-y$	d^2
Algeria	23.99	4	76.39	6	-2	
Bangladesh	21.61	7	70.65	10	-3	
Barbados	11.97	12	74.99	8		16
Brazil	14.72		73.28	9		0
Cambodia	24.40		63.78			
Canada	10.29		81.67		12	144
Costa Rica	16.08	8	78.23		4	16
France	12.49		81.66		9	81
New Zealand	13.40		80.93	3	7	49
Poland	9.77	14	76.65	5	9	81
Syria	22.76	6	68.41	11	-5	25
Tajikistan	24.99	2	67.06	12	-10	100
Tonga	23.55	5	75.82	7	-2	4
Zambia	42.46	1	51.83	14	-13	169

[5]

(iii) Carry out the hypothesis test using Spearman's rank correlation coefficient.

Use a 5% significance level.

[3]

(d) The student uses software to work out the product moment correlation coefficient for birth rate and life expectancy for all countries.

The result is -0.84.

Make **two** comments about this figure. **[2]**

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Sample answer for question 6 (c) and (d)

(c) (i) H_0 = life expectancy and birth rate are not connected in any way

H_1 = life expectancy and birth rate are connected in some way

(ii)

Country	Birth rate	Rank, x	Life expectancy	Rank, y	$d=x-y$	d^2
Algeria	23.99	4	76.39	6	-2	-4
Bangladesh	21.61	7	70.65	10	-3	-9
Barbados	11.97	12	74.99	8	4	16
Brazil	14.72	9	73.28	9	0	0
Cambodia	24.40	3	63.78	13	-10	-100
Canada	10.29	13	81.67	1	12	144
Costa Rica	16.08	8	78.23	4	4	16
France	12.49	11	81.66	2	9	81
New Zealand	13.40	10	80.93	3	7	49
Poland	9.77	14	76.65	5	9	81
Syria	22.76	6	68.41	11	-5	25
Tajikistan	24.99	2	67.06	12	-10	100
Tonga	23.55	5	75.82	7	-2	4
Zambia	42.46	1	51.83	14	-13	169
					Σd^2	572

$$r_s = 1 - \frac{6 \times 572}{14 \times (14^2 - 1)} = -0.2571$$

(iii) The r_s critical value for two tailed 5% = 0.5385

-0.2571 > -0.5385 so the value is not significant.

(d) The product moment result would imply that there is a strong negative correlation between the two variables.

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Commentary on the answer

(c) (i) In this answer the hypotheses have not been stated correctly. The null hypothesis should be “There is no association between birth rate and life expectancy”.

(ii) The d^2 values have been calculated incorrectly, possibly due to missing out brackets when squaring the negative d values. This has resulted in a much smaller test statistic.

(iii) The correct critical value has been used, and the incorrect value of the correlation coefficient has been correctly compared with it. However, having decided that the result is not significant, the conclusion has not been expressed in relation to the original context.

(d) The answer recognises that there is a strong negative correlation, but it has not been related to the context.

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Summary of updates

Version (Date of issue)	Section	Change
Version 1.0 (03/2023)		
Version 2.0 (11/2025)		Our Sample Assessment Materials have been updated as part of our accessibility principles and to reflect our live assessment materials. These resources are based on the Sample Assessment Materials, so some questions have been restructured or re-worded and the candidate style responses have been revised accordingly.

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